VOLUME 77 SEPARATE No. D-47

PROCEEDINGS

AMERICAN SOCIETY
OF
CIVIL ENGINEERS

NOVEMBER, 1951

DISCUSSION OF OPERATION AND MAINTENANCE OF IRRIGATION SYSTEMS

(Published in December, 1950)

By George W. Howard, Lyman R. Flook, Jr., Rudolfo E. Ballester, Alfred R. Golze, and Raymond A. Hill

IRRIGATION DIVISION

Headquarters of the Society
33 W. 39th St.
New York 18, N.Y.

PRICE $0.50 PER COPY

GUIDEPOST FOR TECHNICAL READERS

"Proceedings-Separates" of value or significance to readers in various fields are here listed, for convenience, in terms of the Society's Technical Divisions. Where there seems to be an overlapping of interest between Divisions, the same Separate number may appear under more than one item.

Technical Division	*Proceedings-Separate Number*
Air Transport	42, 43, 48, 52, 60, 93, 94, 95, 100, 103, 104 (Discussion: D-XXVIII, D-7, D-16, D-23, D-18, D-43)
City Planning	58, 60, 62, 64, 93, 94, 99, 101, 104, 105 (Discussion: D-16, D-23, D-43)
Construction	43, 50, 55, 71, 92, 94, 103 (Discussion: D-3, D-8, D-23, D-17, D-36, D-40)
Engineering Economics	46, 47, 62, 64, 65, 68, 69, 95, 100, 104 (Discussion: D-2, D-19, D-27, D-30, D-36)
Engineering Mechanics	41, 49, 51, 54, 56, 59, 61, 88, 89, 96 (Discussion: D-5, D-XXIII, D-XXV, D-18, D-24, D-33, D-34)
Highway	43, 44, 48, 58, 70, 100, 105 (Discussion: D-XXVIII, D-7, D-16, D-23, D-13)
Hydraulics	50, 55, 56, 57, 70, 71, 78, 79, 80, 83, 86, 92, 96 (Discussion: D-XXVII, D-9, D-11, D-19, D-28, D-29)
Irrigation	46, 47, 48, 55, 56, 57, 67, 70, 71, 87, 88, 90, 91, 96, 97, 98, 99, 102 (Discussion: D-XXIII, D-3, D-7, D-11, D-19, D-25-K, D-29, D-17, D-30, D-38, D-40, D-44, D-47)
Power	48, 55, 56, 69, 71, 88, 96, 103 (Discussion: D-XXIII, D-2, D-3, D-7, D-11, D-19, D-25-K, D-17, D-30, D-38, D-40, D-44)
Sanitary Engineering	55, 56, 87, 91, 96 (Discussion: D-10, D-29, D-37)
Soil Mechanics and Foundations	43, 44, 48, 94, 102, 103 (Discussion: D-4, D-XXVIII, D-7, D-43, D-44)
Structural	42, 49, 51, 53, 54, 59, 61, 66, 89, 100, 103 (Discussion: D-5, D-3, D-8, D-16, D-23, D-13, D-21, D-24, D-25-K, D-32, D-17, D-33, D-34, D-39, D-42, D-37)
Surveying and Mapping	50, 52, 55, 60, 63, 65, 68
Waterways	41, 44, 45, 50, 56, 57, 70, 71, 96 (Discussion: D-XXVII, D-9, D-8, D-19, D-27, D-28)

A constant effort is made to supply technical material to Society members, over the entire range of possible interest. Insofar as your specialty may be covered inadequately in the foregoing list, this fact is a gage of the need for your help toward improvement. Those who are planning papers for submission to "Proceedings-Separates" will expedite Division and Committee action measurably by first studying the ASCE "Guide for Development of Proceedings-Separates" as to style, content, and format. For a copy of this Manual, address the Manager, Technical Publications, ASCE, 33 W. 39th Street, New York 18, N. Y.

Published at Prince and Lemon Streets, Lancaster, Pa., by the American Society of Civil Engineers. Editorial and General Offices at 33 West Thirty-ninth Street, New York 18, N. Y.

DISCUSSION

GEORGE W. HOWARD,[2] M. ASCE.—This excellent paper presents in a straightforward manner the numerous problems confronting the operators of irrigation systems.

To those individuals having a direct interest in the costs of operation and maintenance, the involved system of government bookkeeping frequently results in confusion. Perhaps this type of accounting procedure causes the apparent lack of interest in cost accounting referred to by Mr. Hill; and when control of the district is taken over from the Bureau of Reclamation, United States Department of the Interior (USBR), the water users employ the absolute minimum of bookkeeping required to keep their accounts legible to the members of the using association. Certainly it is not economically feasible for an independent organization to adopt the involved accounting system used by the government, for the expenses connected with the cost accounting would probably exceed their benefits. As a result of the many legal restrictions placed on the USBR, however, it is necessary that the more elaborate system be used when a project is operated by the USBR.

TABLE 2.—OPERATING EXPENSES OF THE RESERVATION DIVISION, YUMA PROJECT, ARIZONA–CALIFORNIA (IN DOLLARS).

Item	1946	1947	1948	1949	1950
Delivery system	$1,873	$3,253	$2,811	$9,709	$4,228
Distribution system	39,398	41,008	50,063	39,631	86,097
Drainage system	200	5,589	1,318	1,821	15,597
Total irrigation operation and maintenance	50,397	62,595	69,966	57,925	119,696
Replacements and improvements	....	....	....	....	18,598
Total irrigation cost	$50,397	$62,595	$69,966	$57,925	$138,294
Minimum water rate, in dollars per acre[a]	3.00	4.00	6.00	6.00	6.00

[a] Based on a minimum usage of 4 acre-ft.

The Bard Irrigation District, Imperial County, is the California part of the Yuma (Calif.) and Arizona Reclamation Project of 67,400 acres. The Reservation Division of this project, of which the Bard Irrigation District is a part, has 7,743 acres of Indian lands and 6,287 acres in the Bard Irrigation District. It is still operated by the USBR and efforts to understand the financial outlay chargeable against this district result in many headaches for the board of directors. Although the USBR operates the district, the directors represent the people who are the actual water users and who pay the expenses incurred in operating the project. Excellent cooperation is obtained from the USBR,

NOTE.—This paper by Raymond A. Hill was published in December, 1950, as *Proceedings-Separate No. 47*. The numbering of footnotes and tables in this Separate is a continuation of the consecutive numbering used in the original paper.

[2] Chf., Technical Service Dept., Eng. Research and Development Laboratories, Fort Belvoir, Va.; Director, Bard Irrigation District, 1949.

but the board of directors of the Bard Irrigation District is placed in the awkward position of lending approval to expenditures after-the-fact and of having no voice in the policies connected with administration of the district.

Operating expenses of the reservation division of the Yuma project for the years 1946–1950 are shown in Table 2, which gives an indication of the increase in operation costs for the last five calendar years. This represents a considerable increase over the $2.26 listed by the author as the cost per acre in 1940. From inspection of the total irrigation cost figure in this table, it is evident that the $6.00 per acre minimum water rate will not continue long.

The basic principle indicated in this paper is met in the Bard Irrigation District; that is, that enough water is delivered to each farm at the right time to satisfy all beneficial needs without waste. It is still a very evident fact and a cause of great concern to all water users that unless the minimum water rate per acre is kept as low as possible, the resultant operating expenses of irrigation projects are going to cause real financial hardship.

LYMAN R. FLOOK, JR.,[3] JUN. ASCE.—A discussion of the operational water wastes in irrigation systems is given in this paper, with an accurate description of how waste originates during thunderstorm activity. A large quantity of water is wasted in this manner, but a more complete list of operating waste for irrigation projects in the Southwest would include: (*a*) Reservoir losses; (*b*) evaporation and transpiration losses along the distribution system; (*c*) excessive water orders; (*d*) climatic changes; (*e*) unwillingness to irrigate at night; (*f*) structure failures; (*g*) communications breakdown; and (*h*) excessive releases to speed delivery.

(*a*) *Reservoir Losses.*—Evaporation and transpiration for the storage reservoirs and contiguous vegetation may be more than 30% of the irrigation release in a year.

(*b*) *Evaporation and Transpiration Losses Along the Distribution System.*—Water is lost from the free water surfaces of canals, laterals, and ponds to rank vegetation growing along the distribution system. Good maintenance practice reduces these losses to a minimum.

(*c*) *Excessive Water Orders.*—Unrealistic and often excessive water orders are placed by farmers for a variety of reasons. The average farmer on irrigated land cannot be expected to place consistently accurate water orders. When water charges are relatively low compared to his other operating costs, and particularly when he is charged only for water used and not for water ordered, excessive water orders are to be expected. Farmers will actually divert and pay for excessive volumes of water, much of which is wasted. Then, when a high demand period occurs, the farmer can obtain an immediate increase in his individual water supply by simply reducing his normal waste. Since wastes are frequently rediverted to meet the needs of lower users, this action further exaggerates water delivery problems during a high demand period.

(*d*) *Climatic Changes.*—These changes are thoroughly discussed by the author in the section on "Operating Wastes."

[3] Engr., International Boundary & Water Commission, El Paso, Tex.

(*e*) *Unwillingness to Irrigate at Night.*—Refusal to use available water at night or other inconvenient times results in wastes from the lower division of a project. Wastes from the upper division are often usable since they are redivertable. It is impractical to attempt to schedule reservoir releases several days in advance to eliminate arrival of irrigation water at night.

(*f*) *Structure Failures.*—Canal breaks and other structure failures, that usually occur during periods of peak water demand, cause water to be available at diversion points without sufficient notice and at unusable rates.

(*g*) *Communications Breakdown.*—During thunderstorm activity, the long telephone lines from a headquarters office to the point of irrigation release may go out of service. This results in delay in ordering changes in irrigation release and aggravates water loss caused by storms.

(*h*) *Excessive Releases to Speed Delivery.*—Occasionally, during periods of hot weather, the water demand exceeds the capacity of the system to supply it. Then it becomes necessary to release excessive amounts of water from storage to reduce the travel time of the release through the system to the lower water users. The excess releases are wasted below the lower end of the project.

Any enumeration of causes of water loss on irrigation projects is of little value unless it points the way to reducing unnecessary losses. Obviously, the best time to create an efficiently operating irrigation system is in the original planning and design of the system. As full stream-flow utilization is approached, an excellent opportunity exists for designing irrigation systems that can be operated with minimum waste. Those charged with the responsibility of laying out irrigation systems should be fully aware of all important operating problems likely to arise.

One of the best methods of obtaining flexibility in a system, a method often overlooked, is mentioned by the author in the section on "Operating Waste." This is to provide short-term reservoir storage capacity near the end of the main canals. The capacity need not be large compared to the long-term storage capacity supplying the system, but wherever the point of initial irrigation water release is far from the point of use, waste is inevitable unless some storage capacity is provided near the point of use.

Given a well designed and constructed system, adequate funds and competent personnel must be obtained to insure adequate protection of the original investment and continuous efficient operation. Too often a good irrigation system is allowed to degenerate, and ultimatly to require heavy expenditures, in the interest of short term economy.

RODOLFO E. BALLESTER[4].—A very interesting problem is called to the attention of engineers in this paper. "The maintenance of irrigation projects is a highly important function, and essentially a technical job * * *" as stated in the section "Maintenance of Works." Engineers have at their disposal an extensive and varied literature covering structures from dams to canal linings, but very few or no references concerning the technique and methods of operation and maintenance of irrigation structures. It would seem that engineers prefer to pass the burden of this type of job to the water users.

[4] Prof. of Applied Hydraulics, Univ. of Buenos Aires. Buenos Aires, Argentina.

The author calls attention to some additional points: measurement of water, delivery of water for beneficial use, and rigid control of all releases from dams to the farm laterals. The writer thinks that the last two points cannot be accomplished if the first is not realized. Under the heading "Measurement of Water," the author states that "* * * measurements of water delivered to farm headgates are generally little better than guesses."

The writer has had a very interesting experience on one of the irrigation systems of Argentina. The "Centenario" ("Neuquen") system is operated in rotation from laterals. The discharge for each lateral was measured at the headgates, with all the complications of measuring the opening, upstream head, downstream head, and fixing the coefficient of discharge for free or submerged orifice. There were always differences with the water users about the true quantity delivered. On three laterals, just below the headgates, standing wave flumes were installed with scales graduated in liters per second. The first reaction of the water users was that water delivery would be diminished. They said that the reduction of section of the lateral caused by the flume would reduce the discharge. However, after a year of operation, instead of asking for delivery in terms of centimeters of opening of the headgate, they asked for a quantity of liters per second. The most illiterate farmers started to think in terms of volume of discharge instead of gate openings. A water user even built a flume at his own farm to control the general delivery.

To the watermaster or superintendent, the record of the flume discharge was very useful for the quantitative consideration of the requirements of the lands served by the laterals and for the preparation of the program of deliveries for the whole system.

Of the various systems of water distribution the rotation system is the most rational. In the Centenario system water was delivered at the start of cultivation using the continuous flow system. The headgate of each farm had a padlock under the "zanjero" control for keeping a fixed opening. Later, the system was changed to rotation with a schedule of deliveries to each farm fixed at the beginning of the water year. Padlocks were removed. Now each water user opens his headgate at the time fixed in the schedule. The rotation system is not applicable to smaller canals, as the author states, because larger sections are necessary to carry the accumulated discharge that occurs in a shorter time.

The chief problem in the maintenance of canals and open drains is the control of weeds. The writer has observed that irrigation canals with velocities equal to or exceeding the critical velocity given by R. G. Kennedy (neither silting nor scouring) are almost always free of weeds. In open drains the problem is most serious, for it is not possible to maintain a high velocity for weed control. In an irrigation system in which the water is used with high efficiency, the open drains must discharge a very small quantity of water, and this condition favors the growth of weeds.

An irrigation system is comparable to a railroad. Once built, technical progress of every kind must be applied for betterment of service. The maximum beneficial use of water is the ideal of an irrigation system, and to arrive at this goal, cooperation is necessary between water users and engineers.

This paper shows that there are many opportunities for engineers to apply their technical skill in the operation and maintenance of irrigation systems, but they must never neglect the farmers' viewpoint and capacity.

ALFRED R. GOLZÉ,[5] M. ASCE.—In the section devoted to "Costs and Cost Accounting," the opening paragraph states:

> "Little effort is generally made to allocate costs of operation and maintenance. Even the manuals of the USBR are substantially silent in this respect, although many millions of dollars are spent each year on federal reclamation projects alone for such purposes."

It is not known what manual the author had reference to. The USBR in 1949 concluded a revision of its accounting system that makes full provision for the operation and maintenance activities on the Federal Reclamation Projects both for irrigation and for power. For irrigation, accounts are provided to record separately the expenses for storage systems, carriage systems, distribution systems, drainage systems, and general administrative expenses. For the first four elements, costs are separated between operation and maintenance. Operation is further subdivided between labor, supplies, and expenses. Maintenance is subdivided to show cost for physical features, such as reservoirs, dams and waterways; structures, and improvements; and so forth. For general and administrative expenses costs are recorded for office salaries, office supplies and expenses, office furniture, etc.

Expenses are related to operating income in the accounts so that the net income for irrigation can be determined. Cost reports of income and expenses and the relation of the two are made each month for each project operated by the USBR. In addition to maintaining costs under the breakdown cited, each irrigation project operated by the USBR is required to program its anticipated expenditures over a 7-yr period. The components of these programs correspond to and are arranged in the same order as the expense (cost) accounts and constitute the support for the annual budget preparation. The purpose of preparing expenditure programs over a relatively long period is to aid the project personnel in the development of an orderly schedule for replacement of worn-out or obsolete structures and for the replacement of operating equipment such as drag lines. It is obvious that replacement expenditures must not be allowed to "peak" in any 1 year, as they could be too heavy a burden for the water users.

The USBR secures its funds for the operation and maintenance of its irrigation projects from two sources. The Congress annually appropriates part of the money and the remainder is advanced by the water users as trust funds. At the present time (1951) Congress is appropriating about $3,000,000, and the water users are advancing about $2,500,000. It should be understood that 48 of the 65 completed federal projects or divisions of projects are operated by water users themselves at their own expense without reference to the federal government. An example of this is the Salt River Valley Project in Arizona. The principal works operated by the government at this time are

[5] Director, Programs and Finance, Bureau of Reclamation, U. S. Dept. of the Interior, Washington, D. C.

the backbone irrigation facilities of the Central Valley Project in California and reserved works of reservoirs serving both federal and private lands on a number of projects. The only completed irrigation projects wholly operated by the government are the Rio Grande Project in New Mexico and Texas, which the water users have consistently refused to take over, and the Klamath Project in California and Oregon.

For those projects for which appropriations are made by Congress, the benefiting water users are obligated to return the cost annually as determined by the Bureau's accounting system. As a general rule the government recovers the cost of operation and maintenance chargeable to appropriated funds within 12 months from the time in which the expenditures are made.[7]

RAYMOND A. HILL,[6] M. ASCE.—The discussion by Mr. Flook is largely an amplification of the causes for operating waste. It is not believed that the first two of the eight causes listed by him (reservoir losses and evaporation and transpiration losses along the distribution system) should be classified as operating waste. Such evapo-transpiration losses cannot be reduced materially by improvements in operating procedure. Although failure of structures and breakdown of communications may occasionally contribute to the volume of operating waste and provision should be made to prevent such losses by design of adequate works, it hardly seems appropriate to include these in the classification of operating waste. Except for these matters of terminology, the writer agrees fully with Mr. Flook.

The comments of Mr. Ballester should be particularly informative to engineers in this country because they are prone to think that their methods are the most advanced. The writer was surprised, however, to note that the rotation system of deliveries had superseded the demand system (with apparent approval of the farmers) in the irrigation system in Argentina. It may be that the quantity of water available there for deliveries in rotation is sufficient to meet the maximum requirements on individual farms regardless of climatic changes. Generally, however, it is believed that the delivery of enough water to meet crop requirements cannot be made under a rigid time schedule, fixed at the beginning of the water year, without substantial operating waste.

The remaining two discussions of the original paper have to do with costs of operation and maintenance. In amplification of the tabulation given by Mr. Howard it is to be noted that the unit cost per acre on the Reservation Division of the Yuma Project has increased from $2.26 in 1940 to $3.60 in 1946 and to $8.50 in 1950, exclusive of costs of replacements and improvements.

The objection made by Mr. Golzé to the reference by the writer to manuals of the USBR is proper, and the original statement warrants explanation. The manuals and other data obtained from the USBR at the time of preparation of the paper in 1949 did not include the edition of the manual to which Mr. Golzé refers. Neither was it intended to give the impression that many millions of dollars are spent each year by the USBR for operation and maintenance, as it was realized that many federal projects or divisions of projects are operated

[7] "Operation and Maintenance Costs and Gross Crop Values per Irrigated Acre—1949," Bureau of Reclamation, U. S. Dept. of the Interior, Washington, D. C., pp. 1–3.

[6] Cons. Engr., Leeds, Hill, and Jewett, Los Angeles, Calif.

by the water users themselves. The fact remains, however, that the federal government can and does exercise considerable control over the operations of all projects built by the USBR.

It appears from the description of the irrigation accounts now in use on federal reclamation projects that these accounts are fundamentally the same as those that have been used on the Salt River Project since 1943. These were patterned on the standard accounts prescribed by the Federal Power Commission for utilities coming under its jurisdiction. This system of accounts has the great advantage of being usable by any operating entity, regardless of size. Such detailed accounts as those described by Mr. Golzé can be kept wherever such detail is warrented by the magnitude of the costs; on the other hand, even a very small project can maintain the control accounts listed in Table 1.

There is a disposition on the part of most organizations of water users on irrigation projects to keep no accounts beyond a record of income and disbursements. On the other hand, every privately owned domestic water company must report its costs in considerable detail to its state regulatory body, and most municipal water companies make similar reports. The costs of operation and maintenance of domestic water companies are in the same order of magnitude as those incurred in the operation and maintenance of irrigation systems. It is believed that the same benefits would accrue to irrigation districts and water users' associations if their records of account were kept in sufficient detail to permit effective management control of such costs.

Mr. Golzé refers to the development of an orderly schedule for replacement of worn-out or obsolete structures and for the replacement of operating equipment. So great has the need for replacements become on many federal reclamation projects that the cost of such replacements cannot be met now on a "pay-as-you-go" basis. Accordingly, the USBR is entering into contracts with the water users on many projects that provide for repayments over an extended period of years of the costs of replacements that can no longer be deferred.

In the opinion of the writer, reserves for depreciation should be established on every irrigation project, and the charges to depreciation expense should be sufficient to provide for all replacements of property. All public utilities are required to take depreciation into account; there is every reason why those responsible for the operation of irrigation projects should do likewise. As stated by the United States Supreme Court,[7]

> "Broadly speaking, depreciation is the loss, not restored by current maintenance, which is due to all the factors causing the ultimate retirement of the property. These factors embrace wear and tear, decay, inadequacy, and obsolescence. Annual depreciation is the loss which takes place in a year. In determining reasonable rates for public service, it is proper to include in the operating expense, that is, in the cost of producing the service, an allowance for consumption of capital in order to maintain the integrity of the investment in the service rendered."

[7] "Lindheimer versus Illinois Bell Telephone Company," 292 U.S. 167, 1934.

the backbone irrigation facilities of the Central Valley Project in California and reserved works of reservoirs serving both federal and private lands on a number of projects. The only completed irrigation projects wholly operated by the government are the Rio Grande Project in New Mexico and Texas, which the water users have consistently refused to take over, and the Klamath Project in California and Oregon.

For those projects for which appropriations are made by Congress, the benefiting water users are obligated to return the cost annually as determined by the Bureau's accounting system. As a general rule the government recovers the cost of operation and maintenance chargeable to appropriated funds within 12 months from the time in which the expenditures are made.[7]

RAYMOND A. HILL,[6] M. ASCE.—The discussion by Mr. Flook is largely an amplification of the causes for operating waste. It is not believed that the first two of the eight causes listed by him (reservoir losses and evaporation and transpiration losses along the distribution system) should be classified as operating waste. Such evapo-transpiration losses cannot be reduced materially by improvements in operating procedure. Although failure of structures and breakdown of communications may occasionally contribute to the volume of operating waste and provision should be made to prevent such losses by design of adequate works, it hardly seems appropriate to include these in the classification of operating waste. Except for these matters of terminology, the writer agrees fully with Mr. Flook.

The comments of Mr. Ballester should be particularly informative to engineers in this country because they are prone to think that their methods are the most advanced. The writer was surprised, however, to note that the rotation system of deliveries had superseded the demand system (with apparent approval of the farmers) in the irrigation system in Argentina. It may be that the quantity of water available there for deliveries in rotation is sufficient to meet the maximum requirements on individual farms regardless of climatic changes. Generally, however, it is believed that the delivery of enough water to meet crop requirements cannot be made under a rigid time schedule, fixed at the beginning of the water year, without substantial operating waste.

The remaining two discussions of the original paper have to do with costs of operation and maintenance. In amplification of the tabulation given by Mr. Howard it is to be noted that the unit cost per acre on the Reservation Division of the Yuma Project has increased from $2.26 in 1940 to $3.60 in 1946 and to $8.50 in 1950, exclusive of costs of replacements and improvements.

The objection made by Mr. Golzé to the reference by the writer to manuals of the USBR is proper, and the original statement warrants explanation. The manuals and other data obtained from the USBR at the time of preparation of the paper in 1949 did not include the edition of the manual to which Mr. Golzé refers. Neither was it intended to give the impression that many millions of dollars are spent each year by the USBR for operation and maintenance, as it was realized that many federal projects or divisions of projects are operated

[7] "Operation and Maintenance Costs and Gross Crop Values per Irrigated Acre—1949," Bureau of Reclamation, U. S. Dept. of the Interior, Washington, D. C., pp. 1–3.

[6] Cons. Engr., Leeds, Hill, and Jewett, Los Angeles, Calif.

by the water users themselves. The fact remains, however, that the federal government can and does exercise considerable control over the operations of all projects built by the USBR.

It appears from the description of the irrigation accounts now in use on federal reclamation projects that these accounts are fundamentally the same as those that have been used on the Salt River Project since 1943. These were patterned on the standard accounts prescribed by the Federal Power Commission for utilities coming under its jurisdiction. This system of accounts has the great advantage of being usable by any operating entity, regardless of size. Such detailed accounts as those described by Mr. Golzé can be kept wherever such detail is warrented by the magnitude of the costs; on the other hand, even a very small project can maintain the control accounts listed in Table 1.

There is a disposition on the part of most organizations of water users on irrigation projects to keep no accounts beyond a record of income and disbursements. On the other hand, every privately owned domestic water company must report its costs in considerable detail to its state regulatory body, and most municipal water companies make similar reports. The costs of operation and maintenance of domestic water companies are in the same order of magnitude as those incurred in the operation and maintenance of irrigation systems. It is believed that the same benefits would accrue to irrigation districts and water users' associations if their records of account were kept in sufficient detail to permit effective management control of such costs.

Mr. Golzé refers to the development of an orderly schedule for replacement of worn-out or obsolete structures and for the replacement of operating equipment. So great has the need for replacements become on many federal reclamation projects that the cost of such replacements cannot be met now on a "pay-as-you-go" basis. Accordingly, the USBR is entering into contracts with the water users on many projects that provide for repayments over an extended period of years of the costs of replacements that can no longer be deferred.

In the opinion of the writer, reserves for depreciation should be established on every irrigation project, and the charges to depreciation expense should be sufficient to provide for all replacements of property. All public utilities are required to take depreciation into account; there is every reason why those responsible for the operation of irrigation projects should do likewise. As stated by the United States Supreme Court,[7]

> "Broadly speaking, depreciation is the loss, not restored by current maintenance, which is due to all the factors causing the ultimate retirement of the property. These factors embrace wear and tear, decay, inadequacy, and obsolescence. Annual depreciation is the loss which takes place in a year. In determining reasonable rates for public service, it is proper to include in the operating expense, that is, in the cost of producing the service, an allowance for consumption of capital in order to maintain the integrity of the investment in the service rendered."

[7] "Lindheimer versus Illinois Bell Telephone Company," 292 U.S. 167, 1934.

CURRENT PAPERS AND DISCUSSIONS

Proceedings-Separate Number	Date Available	Title and Author	Discussion closes
67	June, 1951	"Model and Prototype Studies of Sand Traps," by Ralph L. Parshall	Nov. 1
68	June, 1951	"International Cartography," by Robert H. Randall	Nov. 1
69	June, 1951	"Valuation and Depreciation Related to Income Tax," by Maurice R. Scharff	Nov. 1
70	June, 1951	"Regime Theory for Self-Formed Sediment-Bearing Channels," by Thomas Blench	Nov. 1
71	June, 1951	"Rectification of the Papaloapan River in Mexico," by Reynaldo Schega	Nov. 1
72	July, 1951	"Design of Large Coal Bunkers," by Paul Rogers	Dec. 1
73	July, 1951	"Health Implications of Air Pollution," by J. J. Bloomfield	Dec. 1
74	July, 1951	"Acceptable Standards for Natural Waters Used for Bathing," by Charles R. Cox	Dec. 1
75	July, 1951	"Base Course Drainage for Airport Pavements," by Arthur Casagrande and William L. Shannon	Dec. 1
76	July, 1951	"Model Tests Using Low-Velocity Air," by James W. Ball	Dec. 1
77	Aug., 1951	"Buckling Stresses for Flat Plates and Sections," by Elbridge Z. Stowell, George J. Heimerl, Charles Libove, and Eugene E. Lundquist	Jan. 1
78	Aug., 1951	"River Channel Roughness," by Hans A. Einstein and Nicholas L. Barbarossa	Jan. 1
79	Aug., 1951	"Stage Predictions for Flood Control Operations," by Ralph E. King	Jan. 1
80	Aug., 1951	"Mississippi River Valley Geology Relation to River Regime," by Harold N. Fisk	Jan. 1
81	Aug., 1951	"Petenwell Hydroelectric Project," by E. Montford Fucik	Jan. 1
82	Sept., 1951	"Pressures in a Shallow Rectangular Bin," by Raymond L. Moore and J. R. Shaw	Feb. 1
83	Sept., 1951	"Waterway Traffic on the Great Lakes," by John R. Hardin	Feb. 1
84	Sept., 1951	"Longitudinal Mixing Measured by Radioactive Tracers," by Harold A. Thomas, Jr., and Ralph S. Archibald	Feb. 1
85	Sept., 1951	"Resinous Ion Exchangers in Water Treatment," by William W. Aultman	Feb. 1
86	Sept., 1951	"Ground-Water Movement Controlled Through Spreading," by Paul Baumann	Feb. 1
87	Oct., 1951	"Sewage Reclamation by Spreading Basin Infiltration," by Ralph Stone and William F. Garber	Mar. 1
88	Oct., 1951	"Experimental Study of Water Flow in Annular Pipes," by W. M. Owen	Mar. 1
89	Oct., 1951	"Deflections in Gridworks and Slabs," by Walter W. Ewell, Shigeo Okubo, and Joel I. Abrams	Mar. 1
90	Nov., 1951	"Consumptive Use of Water by Forest and Range Vegetation," by L. R. Rich	Apr. 1
91	Nov., 1951	"Consumptive Use of Water," by Harry F. Blaney	Apr. 1
92	Nov., 1951	"Experimental Investigation of Fire Monitors and Nozzles," by Hunter Rouse, J. W. Howe, and D. E. Metzler	Apr. 1
93	Nov., 1951	"Aircraft Design as Related to Airport Standards," by Milton W. Arnold	Apr. 1
94	Nov., 1951	"Friendship International Airport," by Benjamin Everett Beavin	Apr. 1
95	Nov., 1951	"Directional Requirements for Airport Runways," by Ralph H. Burke and Harry Otis Wright, Jr.	Apr. 1
96	Nov., 1951	"Surface Curves for Steady Nonuniform Flow," by Robert B. Jansen	Apr. 1
97	Dec., 1951	"Consumptive Use in the Rio Grande Basin," by Robert L. Lowry	May 1
98	Dec., 1951	"Consumptive Use of Water on Irrigated Land," by Wayne D. Criddle	May 1
99	Dec., 1951	"Consumptive Use in Municipal and Industrial Areas," by George B. Gleason	May 1
100	Dec., 1951	"Forced Vibrations of Continuous Beams," by Edward Saibel and Elio D'Appolonia	May 1
101	Dec., 1951	"Application of Highway Capacity Research," by J. P. Buckley	May 1
102	Dec., 1951	"Utilization of Ground Water in California," by T. Russel Simpson	May 1
103	Dec., 1951	"Pile Foundations for Large Towers on Perma-frost," by L. A. Nees	May 1
104	Dec., 1951	"Redesign of Major Airport Terminals," by Herbert H. Howell	May 1
105	Dec., 1951	"Principles of Highway Capacity Research," by O. K. Normann	May 1

AMERICAN SOCIETY OF CIVIL ENGINEERS

OFFICERS FOR 1951

PRESIDENT

GAIL A. HATHAWAY

VICE-PRESIDENTS

Term expires January, 1952:

FRED C. SCOBEY
ALBERT HAERTLEIN

Term expires October, 1952:

WILLIAM R. GLIDDEN
DANIEL V. TERRELL

DIRECTORS

Term expires January, 1952:

WALDO G. BOWMAN
HAROLD L. BLAKESLEE
PAUL L. HOLLAND
EDMUND FRIEDMAN
S. T. HARDING

Term expires January, 1953:

OTTO HOLDEN
FRANK L. WEAVER
GORDON H. BUTLER
G. BROOKS EARNEST
WALTER J. RYAN*
GEORGE W. LAMB

Term expires October, 1952:

MORRIS GOODKIND
MILTON T. WILSON

Term expires October, 1953:

KIRBY SMITH
FRANCIS S. FRIEL
LOUIS R. HOWSON
WALLACE L. CHADWICK
NORMAN R. MOORE
BURTON G. DWYRE

PAST-PRESIDENTS

Members of the Board

FRANKLIN THOMAS
ERNEST E. HOWARD

TREASURER
CHARLES E. TROUT

EXECUTIVE SECRETARY
WILLIAM N. CAREY

ASSISTANT TREASURER
GEORGE W. BURPEE

ASSISTANT SECRETARY
E. L. CHANDLER

PROCEEDINGS OF THE SOCIETY

SYDNEY WILMOT
Manager of Technical Publications

HAROLD T. LARSEN
Editor of Technical Publications

JOHN C. REHFIELD
Assoc. Editor of Technical Publications

COMMITTEE ON PUBLICATIONS

WALDO G. BOWMAN

FRANCIS S. FRIEL
S. T. HARDING
OTTO HOLDEN
LOUIS R. HOWSON
NORMAN R. MOORE

* Deceased.